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ABSTRACT

The Learning in Science Project established that children from a young age construct out of their everyday experiences views which they use to establish their world and that these views are remarkably resistant to replacement by scientifically more useful views. Although science lessons tend to be based upon activities which are designed by teachers and textbook writers to establish specific scientific viewpoints, experience with these activities does not have the intended influence for many children. Their views, if changed at all, are not changed in the expected way; children remain unaware or unimpressed by the scientific viewpoint. As an alternative to simply accepting these statements as uncovered by the Learning in Science Project, a 30-minute activity on the behavior of particles is provided to help teachers gain first-hand insights into the issues. In addition, a six-item instrument (with answer sheet) and teacher notes are provided to evaluate students' responses to the six questions. Also provided are extracts/examples from 16 lessons analyzed in depth to exemplify aspects of science lessons which have been identified as problems associated with children's classroom experiences and which point to reasons why children do not significantly alter their perceptions about how and why things behave as they do. (JN)

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SCIENCE ACTIVITIES

The Problem

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WORKING PAPER 47

This paper is part of a set of four papers that deal with the work of the Science Activities Action Research Group. The set is:

No.46	Science Activities:	Report on the Science Activities Action Research Group
No.47	Science Activities:	The Problem.
No.48	Science Activities:	Specific Problems - some solutions
No.49	Science Activities:	Wider Issues - Some considerations

RELATED LISP PAPERS

No.	Focus on Experiments
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No.	Visit to a Classroom No.1
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No.	Visit to a Classroom No.3
No.	Visit to a Classroom No.4

SCIENCE ACTIVITIES : THE PROBLEM

Ross Tasker and John Lambert (editors)

December 1981

PREFACE

The work of the Learning in Science Project established that children from a young age construct out of their everyday experiences views which they use to explain their world; and that these intuitive views (which frequently are different from those supported by scientists) are remarkably resistant to replacement by scientifically more useful views. For example, 10 year olds have a much more restrictive view of what is an animal than does a scientist. Take for instance 'is a worm an animal'? Only 10% of Form 1 pupils surveyed classified a worm as an animal. This perhaps is not too surprising; what is surprising is that 40% of sixth form biology pupils similarly surveyed supported the majority Form 1 view that excludes worms from the category animals. For these six formers the years of formal classroom involvement with the term animal have failed to shift their intuitive view of 'what is an animal' to that of the scientist.

These findings raise the following issue.

> Science lessons tend to be based upon activities which are designed by teachers and textbook writers to establish specific scientific viewpoints. Yet, for a number of pupils, experience with these activities does not have the intended influence. Their views, if changed at all, are not changed in the way that is expected. They remain unaware or unimpressed by the scientific viewpoint.

This paper is concerned with the problem inherent in the above issue.

Introduction to the Problem

Two sets of problems are especially associated with activity work in science. The first are logistic problems; problems to do with equipment, laboratory access and management, and the time involved in planning and carrying out the activity. All teachers of science know about these problems and tend to be skilled at dealing with them. The second are to do with pupil learning; problems relating to the nature of the pupils' classroom experience and the impact of that experience on pupils' views. Most teachers are less familiar with problems of this kind and are less skilled at dealing with them.

This paper is concerned with issues related to the second problem set indicated above; issues which became apparent as a result of much time being spent in typical science lessons by members of the Learning in Science Project. The issues are able to be described because, firstly, a large number of primary and secondary school-teachers opened their classrooms to us for the purposes of observing pupils at work. And, secondly, because we adopted an approach to observing the learner in the classroom which focused, not on how well pupils carried out the expected work of the lesson, but on what pupils actually did and said as they worked.

The significance of the research approach adopted was that it provided a perspective of the learner alternate to that readily available to teachers. Most teachers spend a great deal of time and effort monitoring their pupils' involvement in the work set. Unfortunately for teachers, the demands of dealing with around 30 pupils at a time, meeting programme deadlines and directing the lesson allow little time for sustained observation of individuals or for indepth consideration of specific aspects of pupil action and comment. Free of these constraints, we were able to become aware of a number of issues related to why children's views of specific events and/or phenomena are sometimes not influenced (at least in the way expected by teacher and curriculum writer) by classroom experiences designed to achieve the scientific viewpoint.

Relating these issues to your own context

As an alternative to simply accepting the issues as we uncovered them, the teachers in this action-research group found it useful to gain for themselves first-hand insights into the issues by using the following science activity with their classes and then evaluating their pupils response to it with the accompanying survey sheet and notes for teachers. We would urge you to try it. It takes about thirty minutes to complete.

Note: The evaluation guide NOTES FOR TEACHERS - INTERPRETING PUPILS' RESPONSES TO THE CONDY'S CRYSTAL ACTIVITY is on page 8.

The Activity

The activity set out below is an activity in Chapter 3, Order among particles, Science for the seventies I Mark Two, p69, M.J. Petchell, Coronet Books. It is presented exactly as it appears in that text. Although it is important not to shift either the nature of the activity or the framework given it by the title, you should feel free to develop the activity according to your own teaching approach. You will obtain the most useful feedback if the development you adopt closely reflects the typical way the class involved 'does' science.

3.5 Investigating the behaviour of particles

You have already seen some of the things that the particles making up crystals can do when they move from solution back to the solid state again.

In this investigation, if you use some crystals whose particles are strongly-coloured you will be able to observe how they move when they go back into solution.

Equipment needed: beaker of hot water, beaker of cold water, Condy's crystals.

Make sure the water has settled and is not moving at all. Drop one large crystal into each beaker. Watch carefully. What happens to the Condy's in each beaker to start with?
What happens to the Condy's in each beaker after a while?
What was the most important difference between the beakers to start with?
What do you think was the most likely cause of the different results?

In your notebook:

(a) Write the heading.
(b) Draw a diagram of the two beakers. Carefully shade in the Condy's to show how it looked at the end of five minutes.

Copy and complete these sentences:

(c) I think particles in water (can, cannot) move about.
(d) These particles move (more easily, not so easily) if the water is hot.

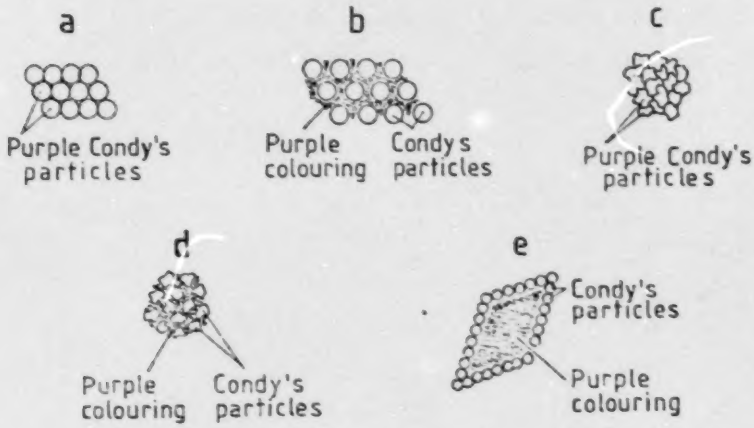
Questions to discuss:

Particles, like other objets, cannot move unless they are supplied with energy. How can the different amount of movement in the hot and cold beakers be explained?

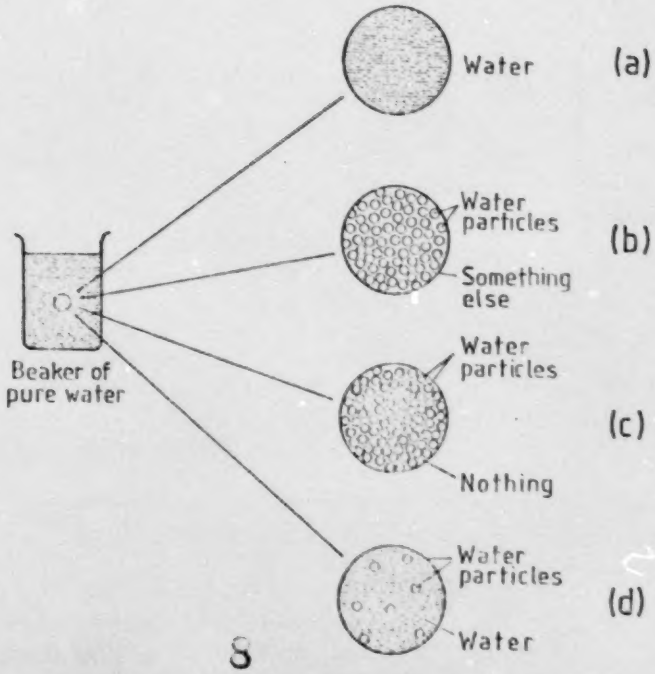
ACTIVITY SURVEY SHEET

The following questions are about the activity in which Condy's crystals are dropped into two beakers, one of hot water and one of cold water.

No. 1 Think of a Condy's crystal as it is before it is dropped into water. Your picture of the particles in Condy's crystals would be closest to which of the following drawings?



No. 2 Your picture of pure water in its finest detail, would be most like which of the following drawings?



No. 3 In your view, the purpose of this investigation was

a) To find out the effect of heat on the behaviour of particles.
b) To find out if Condy's crystals will dissolve in both cold water and in hot water.
c) To find out if both hot and cold water are able to take away the colour from the particles that make up Condy's crystals and if hot water does it best.
d) To find out what happens when the particles making up a Condy's crystal move into solution.

No. 4 How important are the following things in this experiment? (Important, Not Important, Unsure)

a. The crystal needs to be coloured.
b. The two beakers used must be the same size.
c. The two beakers must be filled with the same amount of water.
d. One beaker must have hot water and the other beaker must have cold water.
e. The crystals added to the two beakers must be the same size.
f. The cold beaker must be kept well away from the hot beaker.
g. The two beakers have to be able to be seen through.
h. The crystals should be added to both beakers at the same time.
i. The crystals must not be added until the water in both beakers is settled.

No. 5 Which of the following ideas best fits the way you think about what is happening when a Condy's crystal is dropped into the water?

a. The Condy's crystal sinks to the bottom and the purple colouring in it is slowly squeezed out by water pressure.
b. The particles of Condy's crystal go into the water as the crystal breaks up, and these Condy's particles make the water look purple.
c. Particles of Condy's crystal go into the water and allow the purple colouring to escape from inside the crystal into the water.

No. 6 Four pupils who did this experiment wrote up their thinking about the water as follows. Which one is most like how you think?

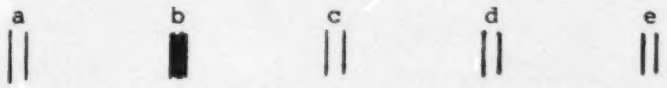
a. Water itself <u>is not</u> made up of particles but particles of other substances move faster in hot water than in cold water.
b. Water itself <u>is not</u> made up of particles but when it is heated, particles of other substances can move easily through it.
c. Water itself <u>is</u> made up of particles and these particles can move about more easily once a colder substance dropped in water is heated up.
d. Water itself <u>is</u> made up of particles and these particles are moving faster when water is hot than when water is cold.

ACTIVITY-SURVEY ANSWER SHEET

NAME.....

FORM.....

For each question (except No. 4) choose the best answer from those provided. If you consider b is best, shade thus:



Should you wish to change your answer, cross out your first choice and shade the letter you now consider best.

Page 1

1. a b c d e

2. a b c d

Page 2

3. a b c d

4. Tick Important OR not Important OR Unsure for each thing (a-i)

	Important	Not Important	Unsure
a			
b			
c			
d			
e			
f			
g			
h			
i			

5. a b c

6. a b c d

NOTES FOR TEACHERS - INTERPRETING PUPILS' RESPONSES TO THE CONDY'S CRYSTAL ACTIVITY

The responses of pupils to this survey should not be interpreted from the perspective we take when marking a typical classroom test, ie. where the concern is to establish whether or not pupils are able to choose the scientifically correct answer. The survey is designed to provide insights into pupils' thinking as it relates to critical aspects of the activity. These insights will be gained if the perspective adopted when examining pupil responses is one that notes just what choice pupils do make from the answers available and then evaluates the significance of those choices.

Questions 1 and 2

Although the activity can be given a number of purposes (and pupils responses must be considered against the framework of the purpose you set) most purposes will relate to the movement of particles. Interview work with children has revealed a number of views for the nature of solids. The scientific view would be (a), but you may find children who think differently. Of particular interest in this activity is to identify those pupils who do not see the purple colour of Condy's crystals as being a property of the Condy's particles (choices b, d and e).

Question 2. From the scientific view this activity is really about the behaviour of water particles (the Condy's crystal particles providing a way of detecting this behaviour). Do children have a particle model for water? and if so, is it the scientific model (c)? or an alternate particle model (b)? Choices (a)and (d) suggest a non-particulate view.

Question 3

Here pupil responses should be considered in terms of your (the teacher's) purpose for the activity. The evaluation of pupils resp .se should be on the basis 'have pupils accepted the purpose I set for the activity?'

Question 4

This experiment looks quite simple to many pupils, but in fact there is quite a lot to it in terms of its design. How many of these design features are appreciated by pupils? In the context of a school laboratory most scientists would see all except (f) as of importance.

Question 5

The observations made by pupils will be mainly associated with the discolouration of the water. What is involved in this effect? Do pupils see this effect in the same way a scientist does, i.e. as the result of purple particles of Condy's crystals going into the water as the crystal breaks up? (b)

Question 6

This question is couched more in the language of the scientist. (d) might be something like the concluding note you may have given your pupils. Did pupils choose it? If not, their choice will tell you about the impact of the activity on their thinking. If so, by considering their response to Q2 in particular, you will get an indication of whether their choice reflects understanding, or the ability to recognize 'the right answer'.

Setting out these problems

In this section extracts and examples from sixteen lessons analysed in depth, are used to exemplify aspects of science lessons which have been identified as problems associated with children's classroom experiences, and which point to reasons why children do not significantly alter their perceptions about how and why things behave as they do. It has been possible to do this only because the teachers concerned were willing that this be so.

Problem 1. There are problems with the lesson being one part of a series of lessons

Lessons are perceived by pupils as isolated events while to the teacher they are parts of a related series of experiences.

Any single science lesson tends to be part of a series of lessons which form the classroom programme for a particular topic. As such, they are viewed by science curriculum writers and science teachers as providing not only a particular experience for pupils and a specific influence on their views, but also as contributing to a set of related experiences designed to have a collective influence. Unfortunately, this broader perception of a single lesson is not recognised by some children.

Example The following extracts come from a lesson concerned with the 'effect of heat on the rate of dissolving'. The task set to inquire into this, involved pupils dropping crystals of potassium permanganate into water of different temperatures and noting what happened.

Teacher perceptions relating to the lesson

T to observer "This is the third lesson in a series aimed at developing a particle idea and going over states of matter ... the first one (lesson) we did was also to do with this. It was to do with expansion and contraction of substances - today was a direct follow on from that."

Pupils perceptions relating to the lesson

O "What was today's one all about?

P "What crystals can do ... we get a card every-so-often (a work card) and we copy from the card. Do an experiment, maybe with crystals."

O "Does today's work have anything to do with this other work you've been doing? (pointing to the pupils open exercise book which was showing notes headed up as the 'dilution of a potassium permanganate crystal' and 'heating and expanding liquids')."

P 'No, not really ... no."

This narrow focus of some pupils is of significance for teachers who draw heavily on previous classroom experiences when setting the scene for an activity at hand. Links which a teacher perceives as strong and obvious, especially if they relate to the scientific ideas taught in previous lessons rather than to what pupils did or what happened, may be far from obvious to pupils whose concern is with what they will have to do today. Another aspect of this problem is that teachers refer to the past in terms of their own perceptions and unfortunately, as will be described later in this section (see (e)), these perceptions are often not those of their pupils.

Problem 2. The lesson has a purpose

The pupil perceived purpose for the task is not the teacher perceived purpose for the task.

It has not been uncommon to find that the teacher's perceptions regarding the purpose of a set task have not been matched by the perceptions of their pupils regarding the purpose of the task. A range of factors appear to operate to bring about this state of affairs in the lessons observed.

a. Some pupils unable or not concerned to perceive a scientific purpose in an activity, limit their intellectual involvement to that needed to simply 'follow the instructions'. This is not surprising perhaps, since it leads to actions which are expected by the teacher and is therefore an effective coping strategy.

Example A 3rd former involved in a unit of work 'The nature of matter' working on an ASEP activity described what he was doing as follows.

P "He (the teacher) talked about it ... That's about all..."

O "What have you decided it (the task) is about?"

P "I dunno, I never really thought about it ... just doing it - doing what it says ... its 8.5 ... just got to do different numbers and the next one we have to do is this (points in text to 8.6)."

The problem with this strategy is that the low level of intellectual involvement in the activity can mean that the outcome accepted by pupils is other than that expected by the teacher, in spite of the teachers' expected cutcome being achieved.

b. In four lessons, the problem appeared to have been the failure on the part of pupils to recognise the purpose of the activity, in the sense that although the teacher purpose was made explicit, either verbally or in written form, pupils nevertheless established an alternative purpose for the activity.

EXAMPLE: A third form class were required to test 8 known solutions in four ways. The instructions for the activity were set-out on the blackboard under the title 'A test for chlorides'. The teacher included in her introduction the following comment.

T "If you note carefully what happens when you do each of the four tests, you will be able to work out how you can tell if a solution is a chloride ... that's what we are trying to do today."

However, this purpose was not clear to a number of pupils.

O "Why did you do this one? ... What was the purpose of it?"

P_1 "Oh ... to find out about chemicals ... acids and all that sort of stuff ... you know, what they are made up of ... and that."

O "What's the purpose of this activity?"

P_3 "To see if these things are acids or alkaline."

O "These things ...?"

P_3 "Yeah (reads from labels) ... sodium chloride ... silver nitrate ... and that."

O "And what if they are?"

P_3 "I dunno ... I suppose we may want to use an acid or an alkaline one day."

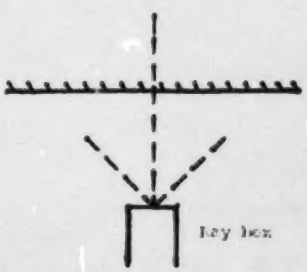
c. Another purpose which pupils assigned when unable to identify a science purpose, occurred when pupils considered they knew the expected outcome; the task then became 'get the right answer'.

Example: Two girls apparently following instructions in a text book used a light ray projected from a ray box to investigate the nature of reflection in a plane mirror.

(i) Pupils perceptions of the task

P_1 to observer "We have got to do this ... do it straight (project a ray at right angles onto the mirror) then you do a dotted line here (marking the position of the ray) and then you've got to go like that (shift the mirror, keeping it at right angles to the projected ray, toward the ray box) and you have to see how many rays of light come off it ... like there is one there, one there and one there ... there should be three ... wait a minute."

(This strategy allows two rays produced by internal reflection in the ray box to be seen and it is these rays that the pupils identify as the expected rays and mark on their diagram (see below).



(ii) Pupils perceptions of significance of outcomes achieved

O "I tried to draw what you had done (shows diagram above) I think you drew it like that (yeah) ... these rays (other than the one which strikes the mirror at right angles) where did they start - at the ray box or at the mirror?"

P "I'm not too sure ... I think they must start there (indicating the ray box) because when the mirror comes down that one is only there and then it starts coming out ... but the mirror made them."

O "If you didn't have the mirror would you get these lines?"

P "No - you'd only get that one line (the original ray)."

The problem with this approach is that pupils tend to ignore good scientific habits, such as being systematic and thinking critically, and simply use any practice which will achieve the perceived goal.

d. On four other occasions, when the explicit purpose stated was recognised by pupils, post lesson discussion with the teacher revealed that this 'public' purpose was, in fact, not the actual purpose for the task. The real purpose, perhaps because it involved skill rather than content objectives, was never stated and remained 'private' to the teacher.

Example: A classroom of 3rd formers are following up a lesson in which they had established a heating curve for tapwater by establishing a similar curve for saltwater.

(i) Teacher's 'public' purpose

T to class: "Right we'll do precisely what we did yesterday - somebody asked 'can we put the results on the same graph that you did for homework (the graph obtained from heating tapwater)' - certainly you can do that as what we are trying to do (today) is compare them isn't it?"

(ii) Pupils' purpose

O: (joining a group of three boys) "This looks interesting".

P_1: "Yeah, we have to ... fill the beaker to 150 ... then um ... get 5ml of salt, then we put it in here (indicating the beaker of water) and then we put it on there (touching the gauze on the tripod) - then we have to take the heat."

O: "I see and what's it all about?"

P_1: I dunno - we just have to do it and get the graph."

(iii) Teacher's 'private' purpose

T to observer: "We needed to use the bunsen the other day and I found some students had never used them, so we digressed from our programme to do something which would develop the skill of using a bunsen - also using a thermometer and we can draw a graph ... We did this (same procedure) yesterday with tapwater and someone said 'I thought water boiled at 100^{o} - so today we are trying heating water with salt and other things in it - reinforcing the skills really."

In the remaining lesson only instructions for carrying out the activity were initially given. A purpose for the activity being publicly stated by the teacher, only after pupils had carried it out simply by following the instructions.

Note: The tendency for pupils to construct as a purpose for a classroom science activity either 'following the set instructions' or 'get the right answer' may be especially associated with written instructional material since it was in classrooms where there was a heavy reliance upon text book activities that this practice was particularly apparent.

Problem 3. The experiment is designed with the purpose in mind

Pupils perceptions of the activity do not include critical design features but teachers assume they do.

To the teacher[1] and curriculum writer the features of the various investigate activities employed in science lessons are clear and designed to elucidate particular aspects of interest: such people have a 'feel' for the activity itself and the nature of the outcome to expect. Pupils, on the other hand often have little or almost no feeling whatsoever for features in the design of an activity and consequently little appreciation of what to expect in the way of outcomes.

Unfortunately, teachers did not often sense this mismatch; they gave instructions which contained design features but almost never, it seemed to the observer, elaborated on their significance. The effect of this lack of feeling in pupils for what they were doing was to greatly enhance the likelihood of a compromise in a design feature of an activity and/or the acceptance of secondary outcomes as the significant outcomes.

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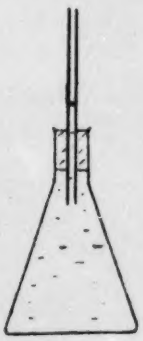
1 Teachers with little background in science sometimes appeared to lack this appreciation.

EXAMPLE: The following extract has been taken from the lesson-record of a Form 1 class investigating the expansion of a liquid. Instructions for the activity were set out on the Blackboard as follows:



Method: Fill the flask with coloured water.
Mark the level of the water in the tube.
Heat the flask using a burner.

Observe what happens to the water level.

Explain why this happens by talking about particles.

To the curriculum writer (the task is a suggested activity in a standard curriculum guide to teachers) the experiment is designed to show change in a marked volume of water, i.e. expansion of liquids. This is achieved in the design by eliminating all possible opportunities for expansion except up the glass tube. The actions of pupils suggested that these design features were not appreciated.

P_1 "You've filled it up too much (having difficulty in forcing the stopper with its glass tubing into the flask full of water)."

P_2 "Tip some out (P_1 does just that)."

Tipping some water out of the flask did make the job of fitting the stopper easy; unfortunately, it also meant that the glass tube was not below the surface of the water in the flask. They then started to heat the water. The teacher noticed another group who had also not met the expected design requirements and made a passing reference.

T "make sure that some of the green water can be seen up the glass tube".

This prompted the pupils in the observed group to again try and push the glass tube further through the stopper. However when this proved too difficult, they simply put the flask without the stopper back on the burner. By the time the teacher noticed what the group were doing, the water was boiling vigorously. In an attempt to recover the situation the

teacher picked up the stopper and succeeded where the pupils had failed in pushing the glass tube further through the stopper and fitted it into the beaker; then said "right you can see where the water is now" and moved on. This action prompted P_4 to say, "Hey that's not gonna work because that's in the water". But already something had happened because steam in the tube had condensed and water was dripping out of the end of the plastic tubing.

P_4 "Look it's going down ... dripping."

P_5 "Sort of steam."

No one said anything about water levels.

An associated factor to the state of affairs described above, is an apparent lack of familiarity on the part of some pupils with some items of equipment and materials involved in science activities.

Example: Pupils had their own views about bimetallic strips,

O "Why do you think the strip bends that way?"
P "The metal must have been made in one way."
O "Is the strip made up of just one type of metal?"
P 'No, the handle is different."

Furthermore, pupils have lacked skills required to achieve some design features expected, e.g. pupils required to measure out 10mls of water showed no appreciation of how to cope with the curved miniscus effect and no awareness of parallax error, their 'measured' 10mls actually ranged from 7mls to 12mls.

Problem 4. Pupils have different views

The views of pupils against which they consider the actions and outcomes of activities are not the teacher assumed views.

Teachers make assumptions regarding the views pupils hold about phenomena associated with an activity which are unjustified for at least some pupils. The economics of the classroom and the syllabus may demand

the making of assumptions. However what seems clear, is that the extent and nature of these assumptions are not appreciated by teachers. The examples cited below are included because in the context of the various lessons they had a marked influence on the nature of the pupils classroom experience.

a. pupils lack assumed prerequisite knowledge.

EXAMPLE: A group of 6 pupils in a Form 2 class studying a wasteland area as part of the classes work on 'Biological Communities' were given the task of finding and collecting 'Decomposers'. Without any hesitation the group picked up two plastic containers and a hand-trowel from a selection of available equipment and headed outside to the study area.

O "(After 10 minutes of activity) How's it going?"

P_1 "We've got a snail, a worm and a..... something else (centipede)."

O "Have we got the things we want?"

P_1 "Yeah, I think so.....I'm sure about the worm anyway."

b. pupils are unable to grasp the 'mental set' required.

Sometimes the classroom experience of a pupil can be considerably influenced by an intuitive view he or she holds without the teacher being aware.

EXAMPLE: To illustrate this problem extracts are presented from the lesson-record 'Properties of oxygen' where the intuitive viewpoint 'if you can't see it then it doesn't exist' was a key determinant in what pupils took from that classroom experience.

T "S[illegible]ply heat the potassium permanganate in the flame and it produces oxy[illegible]n" (demonstrates)

P "There's nothing there" (not being able to see the colourless gas)

and later, after the pupil has carried out the task.

O "Have you decided whether it supports combustion or not?"

P "It doesn't ... because when we put that (the lighted splint) in there (in the test-tube) it doesn't burn."

O "What does the 'it' refer to?"

P "I suppose it means that stuff (pointing to the potassium permangante crystals)."

O "Finished?"

P "Yeah."

O "Was it all right?"

P "Pretty clear."

Problem 5. Pupils have difficulty relating what they do and see happen to their thinking

The pupils' perceptions relating to the significance of activity outcomes achieved are not those the teacher assumes are perceived.

As has been illustrated in previous parts of this section, many factors operate to influence just what pupils recognise as the significant outcomes from their involvement with a classroom science activity. However, all of the factors identified above reduce the influence of the classroom experience on the pupils' viewpoint. What makes science teaching based on pupil involvement with investigative activities so difficult is that any one factor is often sufficient to prevent pupils having the expected experience.

Even in situations where pupils appreciate the;

- lesson is related to proceeding lessons,
- the teacher's purpose for the activity,
- the design features of the activity, and
- the various phenomena associated with the activity,

they still do not necessarily have their child's viewpoint influenced in the way intended by the teacher or curriculum writer. For example, the results in some experiments are not always those that a scientist would predict and hence the influence of these experiences is not in the direction intended. Observations suggest that often neither support of a pupils achievement in obtaining an answer, nor careful distinction and isolation of the answer from the scientific answer, is made.

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Problems that occur in science lessons

The problems set out in the previous section can be summarised in a way which contrasts the teacher's viewpoint with that of the pupil.

	Some possible mismatches between teacher and pupil preceptions. It would be extremely rare for all these to occur in any one lesson		Some consequences of the mismatch (if it does occur).
Relating to setting the scene of the lesson	Teacher's Viewpoint	Pupil's Viewpoint	
a. Scientific context of the lesson/activity	The lesson/activity is seen as part of a related series of experiences	The lesson/activity is seen as an isolated event.	Pupils do not consider the lesson/activity against important prior experiences.
b. Scientific purpose of the lesson/activity	The scientific purpose of the lesson/activity is specific and obvious.	The purpose of the lesson/activity is not obvious.	Pupils guess at and invent what seems to them to be a reasonable purpose.
c. Scientific design of the investigatory activity	The activity has certain critical scientific features which enable particular ideas to be tested.	The critical scientific features of the activity are not recognised or understood.	Pupils are unaware of which aspects of the activity need particular attention and why.
Relating to pupils			
a. Doing the activity	What the pupils are to do is obvious and requires skills the pupils possess.	What to do is not understood and the skills needed are not available.	Pupils do things which they think appropriate to reach the end of the activity.
b. Getting results	Pupils know what to look for and will recognise the result of the activity.	What to look for and how important a result is, is not clear.	Pupils focus on, and observe, unexpected aspects of the activity. They are preoccupied with "What is supposed to happen?"
c. Thinking about what was done and what happened	Pupils will consider critically their actions and findings.	There is no awareness that actions and findings should be critically examined.	Pupils see the activity as 'getting the right answer' or guessing what the teacher wanted from the activity.
Relating to outcomes achieved			
a. Evaluation of the experience	Pupils will consider the experience against the ideas and perceptions of scientists' science.	The experience if considered against ideas and perceptions of childrens' science.	Pupils have difficulty relating what they did and saw happening to their thinking.
b. Significance of the experience	There are pre-determined outcomes which are significant for achieving the teachers aim.	The significant outcomes are not detected or detectable because they do not relate to the personal view held.	Pupils develop negative attitudes to school science as being not relevant.

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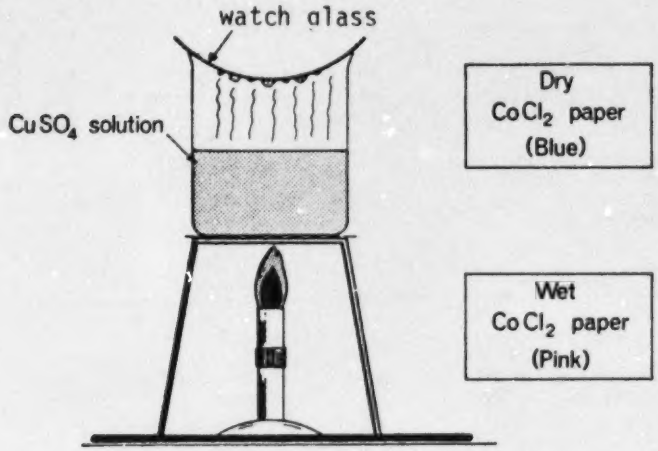
An exercise which we have found provides another opportunity to become familiar with this problem set is to locate in the following extract examples of mismatches described in the table.

THE ACTIVITY:

The following extract comes from a record taken in a Form II classroom at a time when groups of pupils were engaged in a science activity. The activity from a scientist's viewpoint involved evaporating a solvent (water) out of a solution (copper sulphate solution). Pupils were also expected to establish the effect of water on dry cobalt chloride paper and use this knowledge to verify that the condensate they collected was indeed water.

THE INVESTIGATIVE SET UP:



EXTRACT:

O. "How did yours go?"

P.1 "We messed it up?"

P.2 "No ... No, it worked out. (Did it?) Yeah."

P.3 "Despite your [P.1's] bit of mucking up."

P.1 "No, that was your [P.3's] fault."

O. "What happened?"

P.2 "He [P.1] put the paper in there [into the $CuSO_4$ solution] instead of putting a drop of water on it."

O. "Did that muck it up?"

P.2 "No it didn't matter."

P.1 "It turned pink like it was meant to ... it didn't make it go funny."

O. "I see ... can you tell me what happened when you heated the $CuSO_4$ solution?"

P.2 "It boiled up to the inside of that [pointing to the undersurface of the watch-glass].

O. "It boiled up ... what boiled up?"

P.1 "The solution."

P.2 "We boiled the solution and then we turned it over like that [demonstrating with watch-glass] and it [the condensate] made it [dry blue $CoCl_2$ paper] go pink."

O. "What is on there [on the watch-glass]?"

P.2 "Residues."

O. "What are these residues made of?"

P.2 "Water and copper sulphate?"

O. "If I boiled up salt and water what would be on the watch-glass then?"

P.2 "Water and the other stuff ... salt."

O. "So what do you think was happening when you did this one?"

P.2 "The heat was bringing it up ... like hot air rises ... when the water and everything gets hot it rises and it got caught on the glass."

O. "Water and everything?"

P.2 "Water and copper sulphate."